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SAXENA, AKASH	
ART UNIT	**PAPER NUMBER**
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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

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Office Action Summary	Application No.	Applicant(s)	
	10/809,276	CENTALA ET AL.	
	Examiner	**Art Unit**	
	AKASH SAXENA	2128	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 16 June 2009.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 2-9,11-23,25-38,40,45 and 46 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 2-9,11-23,25-38,40,45 and 46 is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

1. Claims 2-9, 11-23, 25-38, 40, and 45-46 have been presented for examination based on applicant's preliminary amendment of 06/16/2009.
2. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 06/16/2009 has been entered.
3. Claims 45-46 are amended.
4. Claims 2-9, 11-23, 25-38, 40, and 45-46 remain are rejected under 35 USC 103.
5. This action is made Non-Final.

Response to Claim Rejections - 35 USC § 103

(Argument 1) Applicant has argued in Remarks Pg.9:

> Initially, Applicant notes that the combination of references (*i.e.*, Beaton, Beaton2, Ma, and Glass) is improper. Beaton and Beaton2 are not applicable to the methods required by the presently amended claims because Beaton and Beaton2 relate only to bi-center drill bits. [A] (Beaton, Abstract and Beaton2, col. 1, lines 16-20). Also, Ma is not applicable because it relates to roller cone bits and Glass is not applicable because it enables only PDC bits. [B] (*See generally*, Ma); (Glass, Background).

(Response 1) As per [A], applicants argument are addressed in the updated rejection below. As per [B], first, applicant has not claimed a specific drill bit and argued unclaimed limitation, i.e. claim applicable to roller cone vs. PDC drill bits. Secondly, although Glass teaches roller cone bits, teachings of Glass are also applicable to roller cone bit. See Glass:

> (37) In various embodiments, various disclosed inventions can be applied to roller-cone as well as fixed-cutter bits.

(Argument 2) Applicant has argued in Remarks Pg.9-10:

> For example, Beaton2 discloses that "the drilling center of conventional bi-center bits tends to fluctuate," and further states that "it is desir[able] to provide a bi-center PDC bit that is capable of drilling a hole larger than its pass-through diameter and that provides superior directional control and steerability." (Beaton2, col. 3, lines 19-21 and lines 26-29). As such, force balancing for bi-center bits focus on achieving directional control and steerability, whereas the methods required by claims 45 and 46 are implemented to reduce bit whirl. Claims 45 and 46 thus require methods of designing drill bits and bottomhole assemblies using radial force measurements. (Present Application, paragraphs [0032]-[0050]). Therefore, methods of force balancing disclo1sed by Beaton and Beaton2 are not applicable to methods required by the present claims.

(Response 2) Applicant is arguing intended use of the <u>force balancing</u> in <u>specific drill types</u> (Bi-center PDC vs. instant claimed drill bit). First intended use does not play a role in the claim interpretation because no specific drill bit is claimed. Further even if the specific drill bit type is claimed (roller cone or PDC), unless the intended use distinguishes structure or exact method steps of force balancing as to how they differ from one drill type to another, it cannot be given patentable weight.

(Argument 3) Applicant has argued in Remarks Pg.10:

> Beaton and Beaton2 are not properly combinable with Glass. Glass is directed to bits having a single cutting structure. (Glass, Background and Figures 2-3B). As discussed above, bi-center bits have a side of the bit with a longer radius than an opposite side of the bit, thus they have at least two cutting structures. <u>In designing a bit having multiple cutting structures, adjustments for each cutting structure are made in relation to the other cutting structures on the bit. Thus, the design methodology for a bit having a single cutting structure is fundamentally different than that for a bit having multiple cutting structures.</u> A person of ordinary skill in the art would have no reason to look to modeling methods for a bit with multiple cutting structures when designing modeling methods for a bit with a single cutting structure. Further, none of Beaton, Beaton2, and Glass teach or suggest looking to modeling methods for bits with multiple cutting structures when designing modeling methods for a bit with only a single cutting structure. Even if Beaton and Beaton2 could be combined with Glass, these references are not properly combinable with Ma, which is applicable only to roller cone bits, as explained in detail below.

(Response 3) Glass discloses single cutting structure and Beaton contrary to allegation, although having more than one cutting structures, treats them as single cutting structure for the purpose of force balancing. Beaton (Abstract) states:

> <u>In another aspect, shapes and positions of the blades and inserts are selected so that lateral forces exerted by the reaming and the pilot sections are balanced **as a single structure**</u>**.**

One of the ordinary skill in the art does not have to extrapolate much from the teachings of Glass to use the teachings of Beaton for balancing the forces as both as fixed cutter drill bits with different designs which are balanced for forces. Beaton2 is further the work of Beaton in the same drill bit type.

(Argument 4) Applicant has argued in Remarks Pg.10-11:

> <u>Beaton and Beaton2 are not properly combinable with Ma because Ma relates to roller cone bits.</u> Roller cone bits use a crushing action to remove rock, cutting the formation by cones rolling around the borehole bottom (rotating about spindles) due to the rotation of the drill bit/drill string. <u>The rolling action of roller cone bits is fundamentally different than the shearing action of the PDL bits of Beaton, Beaton2, and Glass. In other words, roller cone bits have a different cutting action than bi-center bits or PDC bits.</u> The difference in cutting action requires different methods of modeling, and modeling programs for bits having a crushing action are not interchangeable with modeling programs for bits having a shearing action. It is not possible to interchange one type of bit modeling for use on another type of bit; this would result in the modeling being unusable for its intended purpose. Therefore, the combination of Beaton, Beaton2, Ma, and Glass is improper because their respective methods of design may not be incorporated together.

(Response 4) Operations of roller cone bits and PDC bit are known in the art. Examiner is not attempting to interchange the bit types, however the modeling of the bit types have a common premise for force calculation purpose. This teaching is asserted by Glass Col.7 Lines 11-14 as:

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Note that the disclosed inventions are not applicable only to bits for drilling oil and gas wells, but can also be adapted to other rotary drilling applications (especially deep drilling applications, such as geothermal, geomethane, or geophysical sampling bores).

In the presently preferred embodiment the transition is modelled as a direct sharp junction, with no gradation separating the harder rock from the softer rock, but in alternate embodiments the transition can be modelled as a gradation over inches or tens of inches.

<u>In various embodiments, various disclosed inventions can be applied to roller-cone as well as fixed-cutter bits. More generally, the disclosed inventions can be adapted to ANY rock bit or penetrating tool, especially to any fixed-cutter bit,</u> and most especially to any bit which has cutting action (as opposed to crushing).

(Australian Drilli FUNDAMENTAI Moore 1981); Ha ING OPERATIO ING TECHNIQU FIELD DEVEL (1996 translation WELL DRILLIN PRACTICE (198 TIONAL AND H PREVENTION, BALANCED DR tute 1997); the ent Charles Kirkley, e HOLE (1983) and the SPE reprint

Hence Glass provides the motivation to combine the teachings of Ma with Glass and Glass with Beaton & Beaton 2.

(Argument 5) Applicant has argued in Remarks Pg.11-13:

> Further, while the Examiner mentions in passing that Beaton, Beaton2, Ma, and Glass are all directed to drill bit design, the Examiner never identifies why one of ordinary skill in the art would be motivated to combine methods of designing roller cone drill bits with methods of designing bi-center drill bits and methods of designing PDC bits. As indicated above, roller cone drill bits rely on crushing to break formation. Thus, the craters generated by the modeling methods of Ma would be created using a fundamentally different cutting action than the craters generated by Beaton, Beaton2, and Glass. The differences in the cutting action on the formation fundamentally prevent PDC and roller cone bit simulation programs from being interchangeable.

(Response 5) Applicant has argued that crater formed by the roller cone and PDC drill bit are different due to difference in cutting action. First - how the crater are similar or different is not claimed. Secondly, the motivation to combine is defined by the current state of the prior art - i.e. teaching of Glass where it admits the force distribution can be optimized for either roller cone or PDC drill bit the similar way (Glass Col.7 Lines 11-14). Arguments presented on Pg. 12-13 are also addressed as Glass providing teaching for both Roller cone and PDC drill bits and force distribution of both. See Response 3 & 4.

(Argument 6) Applicant has argued in Remarks Pg.14-15:

> Conventionally, forces exceeding a specific amount must be reduced to bring them closer to the magnitude of other similar forces on the bit. (Glass, col. 5, lines 61-63 (stating, "the present application does teach that reducing peak cutter loadings in the transition zone, by balancing cutter loads, is advantageous")); (Beaton, paragraph [0034] (stating, "it has been determined that the drilling stability of a bi-center bit can be further improved by force balancing the entire bit as a single structure")); and (Beaton2, col. 5, lines 5-8 (stating that "the total imbalance force will be the vector sum of the two forces, [either an imbalance force and opposing imbalance force or a circumferential imbalance force and a radial imbalance force]" and to "minimize" this vector sum)). <u>The methods required by the present claims require temporal limitations, for example having a specified amount of time during which a criterion must be met.</u>

(Response 6) Glass clearly shows the force balancing in Fig.3A onwards in the time steps (simulation steps revolutions - x Axis). Arguments for whirl (Remarks: Pg.16) and pre-selected time step (Remarks: Pg.17) are noted. The pre-selected time is

when the forces are in imbalance is successively reduced in Fig.3A to 3B (steps 19-67 reduced to 49-57), thereby meeting the limitation where the adjustment is based on pre-selected time.

(Argument 7) Applicant has argued in Remarks Pg.19:

> The Examiner appears to be engaging in hindsight reconstruction using the present application as a guide, to arbitrarily pick and choose isolated features of Beaton, Beaton2, Ma, and Glass to arrive at the claimed limitations. As noted above, Beaton and Beaton2 are directed to bi-center drill bits and Glass is directed to PDC drill bits, whereas Ma is directed to roller cone drill bits. Furthermore, the limitations arbitrarily selected by the Examiner are from non-analogous art and may not be functional when combined. The fact that the Examiner has combined arbitrary features from non-analogous references is evidence that the Examiner has engaged in picking and choosing of isolated features with no suggestion or motivation to do so.

(Response 7) In response to applicant's argument that the examiner's conclusion of obviousness is based upon improper hindsight reasoning, it must be recognized that any judgment on obviousness is in a sense necessarily a reconstruction based upon hindsight reasoning. But so long as it takes into account only knowledge which was within the level of ordinary skill at the time the claimed invention was made, and does not include knowledge gleaned only from the applicant's disclosure, such a reconstruction is proper. See *In re McLaughlin*, 443 F.2d 1392, 170 USPQ 209 (CCPA 1971). In this case the Beaton & Beaton2 teaches bi-center drill bit which are more closely related to Glass (PDC drill bit) as bi-center drill bit are handled as one for the purpose of simulation (Beaton: Abstract), and Glass teaches force balancing of PDC and roller cone (as taught in Ma) bits alike (Glass: Col.7 Lines 11-14). Therefore there is no-hindsight construction in this case as teachings of each are explicitly taught in the field of force balancing y Beaton, Beaton2, Glass and Ma.

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Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

6. **Claims 2-7, 14-23 and 25-38 are and 45-48 are rejected under 35 U.S.C. 103(a) as being unpatentable over "The Operational Mechanics of The Rock Bit", <u>Ma</u> et al, Petroleum Industry Press, Copyright 1996, further in view of U.S. Patent 6695073 issued to <u>Glass</u> et al, further in view of US PGPUB 20010020552 A1 by Beaton et al.**

The Ma reference is a study of the dynamics of the interaction between the roller cone drill bit and rock (earth) including bit geometry, kinematics, axial loading, and the balancing (equalization) of forces acting on a roller cone drill bit. In particular, Chapter 6, and to some degree Chapter 5, of Ma sets forth the elements of what he refers to as the "New Methodology" for roller cone bit design. This "New Methodology" includes the use of drilling simulation and computer modeling for optimizing the parameters relating to the design of new roller cone drill bits. (See: page 1, paragraph 2, for condensed overview).

The examiner submits that the teachings of Ma render obvious the claimed limitations of the instant invention as presently claimed as follows:

<u>Regarding independent claim 45 (Updated 9/10/09)</u>: *A method for designing a drill bit, comprising:*

- determining radial forces acting on a selected drill bit during simulated drilling; (6.1,

6.1.2.3, 5.3, 3.3 - 3.5, Ma discloses drilling simulation, forces acting on roller cones at least at pages 128, 129, section 5.1)

- evaluating the radial forces based on at least one selected criterion; (Ma teaches forces acting on roller cones at least at pages 128, 129, section 5.1, which would be an inherent part of optimizing the 3-D load model using finite element analysis disclosed in sections 6.1-6.2.3 of Ma. (especially, 6.1.1.5))

- wherein evaluating comprises summing magnitudes of the radial forces with respect to a direction to, generate a sum of the radial forces is a limitation not explicitly taught by Ma and is taught by Glass (Glass: Col.4 Lines 27-56)*;*

- comparing the sum of the radial forces to an applied weight-on-bit is a limitation not explicitly taught by Ma and is taught by Glass (Glass: Col.4 Lines 47-56)*; and*

- generating a ratio between the sum of the radial forces and the applied weight-on-bit is a limitation not explicitly taught by Ma and is taught by Glass (Glass: Col.4 Lines 47-56);

- adjusting at least one parameter of the selected drill bit based on the evaluating; (Ma: 6.1, 6.1.1.1, 6.1.2.3, page 232, lines 6-11, Ma sets forth adjusting design parameters; Glass: Col.4 Line 58-Col.5 Line 11) <u>*until the magnitude of the radial forces is less than a predetermined value for a preselected amount of time for a simulated drilling*</u> as seen in the Fig.3 A (at least) where the window is the selected time period for the simulation where the torque is expressed as the percentage less than certain amount associated with the radial forces.

It would have been obvious to a skilled artisan having access to the teachings Ma at the time of the invention to combine <u>Ma and Glass</u> as both of them are directed towards modeling the drill bit and computing forces which is also a

deficiency in Ma explicitly taught by Glass disclosing programmed calculations of summed orthogonal cutter forces inclusive of weight-on-bit. (CL4-L27-46). Further the motivation to combine is defined by the current state of the prior art - i.e. teaching of Glass where it admits the force distribution can be optimized for either roller cone or PDC drill bit the similar way (Glass Col.7 Lines 11-14).

Glass teaches adjusting at least one parameter (Glass Col.5 Lines 8-24) of the selected drill bit based on the generated ratio (WOB and Torque) and outputting a drill bit design based on the generated ratio and the adjusting.

Even is Ma and Glass are presumed not to explicitly teach outputting a drill bit design based on the generated ratio between the WOB (Fy component in Glass) and radial forces (Fx and Fz force components in Glass) to modify, such suggestion is clearly present in Glass Col.5 Lines 8-24.

Beaton explicitly teaches outputting a drill bit design based on the generated ratio between the WOB in [0035] as:

> [0034] **In another aspect of the invention, it has been determined that the drilling stability of a bi-center bit can be further improved by force balancing the entire bit 10 as a single structure**. Force balancing is described, for example, in, T. M. Warren et al, Drag Bit Performance Modeling, paper no. 15617, Society of Petroleum Engineers, Richardson, Tex., 1986. Prior art bi-center bits were force balanced, but in a different way. **In this embodiment of the invention the forces exerted by each PDC cutters 12 can be calculated individually, and the locations of the blades and the PDC cutter 12 thereon can be selected so that the sum of all the forces exerted by each of the cutters 12 will have a net imbalance of less than about 10 percent of the total axial force exerted on the bit (known in the art as the "weight on bit").** The designs of both the pilot section 13 and the reaming section 15 are optimized simultaneously in this aspect of the invention to result in the preferred force balance. **An improvement to drilling stability can result from force balancing according to this aspect of the invention because the directional components of the forces exerted by each individual cutter 12 are accounted for.** In the prior art, some directional force components, which although summed to the net lateral force exerted individually by the reaming section and pilot section, can result in large unexpected side forces when the individual cutter forces are summed in the aggregate in one section of the bit to offset the aggregate force exerted by the other section of the bit. **This aspect of the invention avoids this potential problem of large unexpected side forces by providing that the locations of and shapes of the blades 14, 1 and cutters 12 are such that the sum of the forces exerted by all of the PDC cutters 12, irrespective of whether they are in the pilot section 13 or in the reaming section 15, is less than about 10 percent of the weight on bit.** It has been determined that still further

> improvement to the performance of the bit 10 can be obtained by balancing the forces to within 5 percent of the axial force on the bit 10.

It would have been obvious to a skilled artisan having access to the teachings Ma at the time of the invention to combine Beaton and Glass as Beaton cures the recognized deficiency in Glass of force balancing the entire PDC drill bit (Beaton: [0034]; Glass: Col.5 Lines 8-24) thereby increasing the stability of bi-center drill bit.

Regarding independent claim 46 (Updated 9/10/09): *A method for designing a bottom hole assembly, comprising:*

- determining radial forces acting on a bottom hole assembly during simulated drilling, said bottom hole assembly including a drill bit. (6.1, 6.1.2.3, 5.3, 3.3 - 3.5, Ma discloses drilling simulation, forces acting on roller cones at least at pages 128, 129, section 5.1, and a bottom pattern modeling at least in Figures 5-20 to 5-32)

- evaluating the radial forces based on at least one selected criterion; (Ma teaches forces acting on roller cones at least at pages 128, 129, section 5.1, which would be an inherent part of optimizing the 3-D load model using finite element analysis disclosed in sections 6.1-6.2.3 of Ma. (especially, 6.1.1.5))

- wherein evaluating comprises summing magnitudes of the radial forces with respect to a direction to, generate a sum of the radial forces is a limitation not explicitly taught by Ma and is taught by Glass (Glass: Col.4 Lines 27-56)*;*

- comparing the sum of the radial forces to an applied weight-on-bit is a limitation not explicitly taught by Ma and is taught by Glass (Glass: Col.4 Lines 47-56)*; and*

- generating a ratio between the sum of the radial forces and the applied weight-on-bit is a limitation not explicitly taught by Ma and is taught by Glass (Glass: Col.4 Lines 47-56);

- adjusting at least one parameter of the bottom hole assembly based on the evaluation (6.1, 6.1.1.1, 6.1.2.3, page 232, lines 6-11, Ma sets forth adjusting design parameters *Glass: Col.4 Line 58-Col.5 Line 11)* *until the magnitude of the radial forces is less than a predetermined value for a preselected amount of time for a simulated drilling* as seen in the Fig.3 A (at least) where the window is the selected time period for the simulation where the torque is expressed as the percentage less than certain amount associated with the radial forces.

Hence, it would have been obvious to a skilled artisan having access to the teachings Ma at the time of the invention to realize the elements of the present invention as currently claimed. An obvious motivation exists since Ma teaches that the elements as claimed, and noted above, can be combined in order to find an optimum design and avoid bit (breakage) failure (chapter 6, section 5.4, especially page 232, based on the entire teaching).

It would have been obvious to a skilled artisan having access to the teachings Ma at the time of the invention to combine Ma and Glass as both of them are directed towards modeling the drill bit and computing forces which is also a a deficiency in Ma explicitly taught by Glass disclosing programmed calculations of summed orthogonal cutter forces inclusive of weight-on-bit. (CL4-L27-46). Further, the motivation to combine is defined by the current state of the prior art - i.e. teaching of Glass where it admits the force distribution can be optimized for either roller cone or PDC drill bit the similar way (Glass Col.7 Lines 11-14).

Glass teaches adjusting at least one parameter (Glass Col.5 Lines 8-24) of the selected drill bit based on the generated ratio (WOB and Torque) and outputting a drill bit design based on the generated ratio and the adjusting.

Even is Ma and Glass are presumed not to explicitly teach outputting a drill bit design based on the generated ratio between the WOB (Fy component in Glass) and radial forces (Fx and Fz force components in Glass) to modify, such suggestion is clearly present in Glass Col.5 Lines 8-24.

Beaton explicitly teaches outputting a drill bit design based on the generated ratio between the WOB in [0035] as:

> [0034] **In another aspect of the invention, it has been determined that the drilling stability of a bi-center bit can be further improved by force balancing the entire bit 10 as a single structure**. Force balancing is described, for example, in, T. M. Warren et al, Drag Bit Performance Modeling, paper no. 15617, Society of Petroleum Engineers, Richardson, Tex., 1986. Prior art bi-center bits were force balanced, but in a different way. **In this embodiment of the invention the forces exerted by each PDC cutters 12 can be calculated individually, and the locations of the blades and the PDC cutter 12 thereon can be selected so that the sum of all the forces exerted by each of the cutters 12 will have a net imbalance of less than about 10 percent of the total axial force exerted on the bit (known in the art as the "weight on bit").** The designs of both the pilot section 13 and the reaming section 15 are optimized simultaneously in this aspect of the invention to result in the preferred force balance. **An improvement to drilling stability can result from force balancing according to this aspect of the invention because the directional components of the forces exerted by each individual cutter 12 are accounted for.** In the prior art, some directional force components, which although summed to the net lateral force exerted individually by the reaming section and pilot section, can result in large unexpected side forces when the individual cutter forces are summed in the aggregate in one section of the bit to offset the aggregate force exerted by the other section of the bit. **This aspect of the invention avoids this potential problem of large unexpected side forces by providing that the locations of and shapes of the blades 14, 1 and cutters 12 are such that the sum of the forces exerted by all of the PDC cutters 12, irrespective of whether they are in the pilot section 13 or in the reaming section 15, is less than about 10 percent of the weight on bit.** It has been determined that still further improvement to the performance of the bit 10 can be obtained by balancing the forces to within 5 percent of the axial force on the bit 10.

It would have been obvious to a skilled artisan having access to the teachings Ma at the time of the invention to combine <u>Beaton and Glass</u> as Beaton cures the recognized deficiency in Glass of force balancing the entire PDC drill bit (Beaton: [0034]; Glass: Col.5 Lines 8-24) thereby increasing the stability of bi-center drill bit.

<u>Per claims 2-7</u>: *Ma renders obvious elements relating to performance parameters and cutting element interaction of a roller cone bit as noted above (6.1, 6.1.1.1, 6.1.2.3, page 232, lines 6-11)*

<u>Per claims 12-13</u>

Beaton teaches the ratio of the sum of the radial forces to the applied weight on bit is less than or equal to 0.10 or 0.05 (Beaton: [0034]).

<u>Per claims 14-23 and 25-35</u>: *The recited box-whisker plot is simply a well-known convenient way of graphically depicting a number summary, which consists of the smallest observation, lower quartile, median, upper quartile, and largest observation (See: CRC, or Wikipedia, for example) and hence would have knowingly been implemented by a skilled artisan in order to graphically depict the summed forces.*

<u>Per claims 36-38</u>: *Ma teaches adjusting bit design parameter (Section 6.1.2.3) and bit parameters (Ma: Chapter 2).*

7. **Claims 8 and 9 are rejected under 35 U.S.C. 103(a) as being unpatentable under <u>Ma</u>, in view of <u>Glass,</u> further in view of <u>Beaton</u>, in further view of US. Patent 6039131 issued to Beaton (<u>Beaton2</u> hereafter).**

<u>Regarding Claim 11</u>

Teachings of Ma, Glass and Beaton are shown in the parent claim 45.

Ma, Glass and Beaton do not explicitly teach the ratio of the sum of the radial forces to the applied weight on bit is less than or equal to 0.20.

Beaton2 teaches the ratio of the sum of the radial forces to the applied weight on bit is less than or equal to 0.20 (Beaton2: Col.3 Lines 7-11).

Hence a skilled artisan would have knowingly modified the teachings of Beaton2 with the teachings of Beaton as Beaton2 is Beaton's own work in an analogous field of PDC drill bit design.

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8. **Claims 8 and 9 are rejected under 35 U.S.C. 103(a) as being unpatentable under <u>Ma</u>, in view of <u>Glass,</u> further in view of <u>Beaton</u>, in further view of "Drag-Bit Performance Modeling, <u>Warren</u> et al, SPE Drilling Engineering, June 1989"**

Analogous art Warren renders obvious elements of the present invention relating to simulating the <u>fixed cutter drill bit drilling an earth formation</u>; (pp. 119, col. 1, para:3-7, pp. 126, col. 1, para:2 to col. 2, para:3, Fig. 6) and determining a cutter-formation interaction force, relative sliding velocity, and cutting surface parameters on a cutter of the fixed cutter drill bit (pp. 19, col. 1, para:6, 7, pp. 126, col. 1, para:2 to col. 2, para:3, Fig. 6, Fig. 6).

Motivation to combine Ma with Glass is presented in the parent claim 45.

Motivation to combine Beaton with Glass is presented in the parent claim 45.

Hence a skilled artisan would have knowingly modified the teachings of Ma with the teachings of Warren, motivated using the same reasoning as previously cited above, to model and implement a fixed cutter drill bit. Ma teaches simulation and computation of forces acting on the drill bit (Ma: Section 5.3 "Simulation Test of the crater forming process by bit teeth" and at least on Pg.202 – as shown on previous page). Ma acknowledges that computer aided simulation and display is anticipated (Ma: Pg.207) analogous to the teaching of Warren (Warren: *pp. 126, col. 1, para:2 to col. 2, para:3, Fig. 6, Fig. 6*) and Glass (Glass: *Col.4 Line 58-Col.5 Line 11*).

Other Relevant Prior Art

9. US Patent 5165494 by Barr (dated Nov 24 1992) acknowledges the computation of the claimed ratio of the lateral (radial) forces and WOB contributing to the whirl effect claimed by applicant and reducing it minimize bit wear (See Background).

Communication

Any inquiry concerning this communication or earlier communications from the examiner should be directed to AKASH SAXENA whose telephone number is (571)272-8351. The examiner can normally be reached on 8:00- 6:00 PM Mon-Thu.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kamini S. Shah can be reached on (571)272-2279. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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